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(54) **Lighting control device**

(57) A lighting device and control means therefor is disclosed. The lighting device consists of a plurality of White LEDs (WLEDs) provided in separate chains all connected parallel. A small number of WLEDs is connected in series in each chain, and a number of such chains are wired together in parallel between a pair of voltage lines from which current is drawn. Current measurement and adjusting means is provided firstly between a high voltage line and all the parallely connected chains, and secondly in each chain. Each current measurement and adjusting means is controlled ideally by a microprocessor which monitors both the total current drawn by all the chains together and also the individual currents flowing in each chain. WLEDs have a tendency to fail when subjected to sudden current increases, and also when operating at extreme temperatures as temperature affects the operating characteristics of diodes in general. It cannot however accurately be predicted whether a particular WLED will fail in open or closed circuit and the invention provides a means of mitigating the effect of failure of one WLED on those which remain functioning in the circuit. The control means immediately increases or reduces the total current flow to all the chains depending on whether a WLEDs fails in short or open circuit. The control means also detects operating temperature and user light intensity requirement and adjusts various currents accordingly.

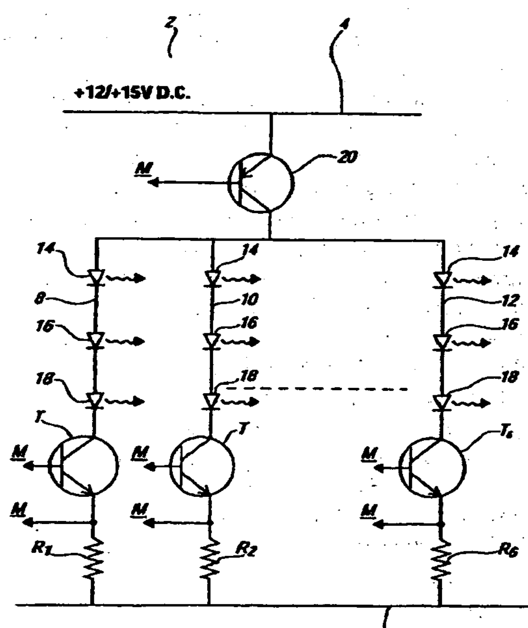

FIG. 1

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Description

[0001] This invention relates to a lighting control device, and more specifically to a control device adapted for use in conjunction with arrays of white light emitting diodes, hereinafter referred to as WLEDs. In particular, the invention hereinafter described has particular application in the field of dedicated aircraft seat lighting, as WLEDs are beginning to replace the fibre optic lighting systems which are currently in widespread use.

[0002] Although the following invention is described with particular reference to the lighting of individual aircraft seats, it is to be pointed out that WLED clusters can be used in any environment where there is a requirement to illuminate a particular and discreet area, and where there is furthermore a requirement for user flexibility and versatility inasmuch as the lighting arrangement must be capable of adopting a number, and perhaps an infinite number of positions and orientations with respect to its mounting. Such lighting arrangements are most ideally suited to providing reading lighting to the occupant of a seat.

[0003] British Patent Application No. 2317421 describes a modular aircraft seat lighting arrangement comprising a plurality of fibre optic cables, ends of which are grouped together in a so-called common end which is illuminated by a high intensity light source, the alternate ends known as fibre optic tails being used to transfer light from the light source to a plurality of different locations. The individual fibre optic cables which connect the tails and the common ends are often bulky and cumbersome, and are thus integrally disposed within or underneath the seats for which they are adapted to provide illumination.

[0004] This arrangement does represent a significant advance over the conventional aircraft seat lighting arrangement in which individual lights are personal lights are incorporated in a mass-produced console unit above each passenger seat on the aircraft, because the fibre optic tails can be sheathed in a flex and stay type member and thus the occupant of a seat can move the tail to any desired position. However, the fibre optic seat lighting arrangement has a number of disadvantages in that the apparatus is bulky, and when it is considered that modern aircraft have seats arranged in banks of three and a lighting arrangement would generally be provided within or underneath each bank of seats, it can be appreciated that the increase in overall weight of the aircraft is significant, especially in longer haul and thus larger aircraft which may have seating for over 400 passengers.

[0005] A further disadvantage of the fibre optic lighting arrangement is its power consumption, which is relatively high on account of the requirement to power the high intensity lights which illuminate the common ends of the cables.

[0006] The recent introduction and customer acceptance of WLEDs has given rise to the development of WLED lighting systems for aircraft, as it is the current belief that WLED systems will displace fibre optic lighting arrangements from their dominant position within the field of aircraft seat lighting. However, the use of WLEDs has heretofore been impeded by their proclivity towards failure, which is generally greater than the proclivity of conventional LEDs to fail. Additionally, LEDs whether WLEDs or otherwise and being essentially diodes can fail in either short circuit or open circuit, an therefore some contingency is required to be factored into any device which depends on the correct functioning of the LEDs or WLEDs to provide light in a particular area. Furthermore, the failure probabilities of WLEDs and LEDs are much higher than the high intensity light sources currently used in the fibre optic lighting arrangements, and therefore some contingency is crucial.

[0007] The applicants herefor have realised that a cluster arrangement of WLEDs having a plurality of WLEDs therein would provide sufficient contingency against total failure of the light because it would be very unlikely for all the WLEDs in the cluster to fail during a single use. Furthermore they have also realised that at least some of the WLEDs within the cluster must be connected in parallel because the open circuit failure of a single WLED if all were connected in series would result in total failure of the light.

[0008] The use of WLEDs has also been previously impeded by the electronic and physical sensitivity of such components. For instance, WLEDs are highly temperature and current sensitive devices, and a slight increase in the operating temperature or electric current being passed can dramatically reduce the life expectancy of the device. It should also be mentioned that diodes being semi-conductor devices have complex temperature dependent resistance, and thus Voltage and Current characteristics.

[0009] A further difficulty associated with the provision of uniform intensity light with WLEDs is that the voltage supplies on aircraft and within vehicles are often non-uniform. The electrical sensitivity of WLEDs and their increased likelihood of failure during the occasional power surges which may be experienced gives rise to the need for some form of compensation to ensure that the working life of the WLEDs is prolonged as much as possible.

[0010] It is therefore an object of this invention to provide a device for monitoring and controlling the operation of a lighting device including a cluster of WLEDs which ensures safe and uninterrupted operation of the device and which can compensate for changes in the operating characteristics of the cluster of WLEDs and for failure of one or more thereof during operation of the device.

[0011] According to the invention there is provided a lighting device comprising a cluster of WLEDs at least some of which are chained in parallel between a pair of lines which apply a voltage across the WLEDs chains, each of said chains having at least one WLED therein, characterised in that first current altering means and second and further cur-

rent altering means are also provided between the lines, said first current altering means being capable of adjusting the total current drawn from the voltage lines by the chained WLEDs and the second and further current altering means being provided in at least one of the chains to adjust the particular current through said chain.

[0012] Preferably, primary current measuring means are also provided between the voltage lines and the chains which measure the total current being drawn by all the WLED chains.

[0013] Preferably, each of the chains is provided with secondary current measuring means which communicate with a control means, preferably a microprocessor operating under the control of a computer program, said control means adjusting the current flow through the WLEDs dependent on a comparison between the measured current through each individual chains, and optionally through the first current altering means.

[0014] Preferably, three WLEDs are connected in series in each of said chains, and most preferably the number of chains is 6 so that the WLED cluster comprises 18 WLEDs.

[0015] Most preferably the current measuring means comprises a resistor connected in series with the series connected WLEDs in each chain, and further preferably the first and second and further current altering means comprise transistors.

[0016] It is yet further preferable that the device is further provided with temperature measurement means which also communicate with the control means which adjusts the current flow through the WLED chains accordingly.

[0017] It is most preferable that the control means dynamically adjusts the current flows through the WLED chains such that the current flow therethrough is substantially uniform and is devoid of discontinuities regardless of the operating temperature and/or the failure of one or more of the WLEDs.

[0018] Preferably the control means, voltage lines, and chained series connected WLEDs are integrated on a single circuit.

[0019] Most preferably, the device is used to provide light for a seat, ideally an aircraft seat which often have sources of power built thereinto, and in this case the device would ideally be powered from said in-built power source.

[0020] Preferably the control means also communicates with an indication means changing the state of same when said control means recognises that one or more of the WLEDs has failed.

[0021] Preferably the indication means comprises a light means emitting a light other than white, said light means being provided in series with gate means also in communication with the control means between the lines, said control means activating said gate means thus allowing current to flow through the light means to illuminate same only when one or more of the WLEDs has failed.

[0022] Preferably said light means is mounted proximate the WLEDs and is visible when the array of WLEDs, one of which has failed, is viewed.

[0023] Preferably the WLEDs and the optional indication means are mounted proximate one another in hexagonal close packed arrangement on a circuit board.

[0024] Preferably the control means is also mounted in said circuit board.

[0025] Preferably the WLEDs are connected within the circuit in groups of three, said group being connected in series as a single chain which is parallely connected with others.

[0026] Most preferably, the grouping of the WLEDs in threes is such that any single WLED is adjacent one other WLED which is connected in series therewith.

[0027] With such a configuration, the open circuit failure on any one of said WLEDs (which would necessarily result in the extinction of the remaining two WLEDs connected in series therewith in a particular chain) could be automatically compensated for in accordance with the invention without significant directional imbalance of light emission from the device.

[0028] Most preferably the WLEDs and optional indication means are mounted on an integrated circuit board comprising wiring and to which said control means is additionally mounted.

[0029] The integrated circuit board is to be considered an independent and separately claimable aspect of this invention.

[0030] Alternatively, the indication means may be provided in a remote indicator panel and directly powered from the control means.

[0031] Yet further alternately, the indicator means may be simply one or more bits in a memory register which is interrogable by a suitably equipped engineer.

[0032] According to a further aspect of the invention there is provided a control means for controlling current flow through a plurality of chains connected parallely between a pair of voltage lines, each of said chains having at least one WLED connected therein, current altering means being additionally connected in each of said chains and current measuring means being also provided in each of said chains which communicate with the control means, characterised in that the current flow through each of the chains is altered dependent on a comparison effected by the control means of the current flows through each of the plurality of chains such that the said current flows are maintained substantially uniform.

[0033] Preferably, at least a single current altering means, and optionally current measurement means are provided

between all of the chains and one of the voltage lines which are capable of altering and measuring respectively the total current flow through the all of the chains.

[0034] Preferably the control means also communicates with user adjustable means for increasing the intensity or dimming the light emitted from the WLEDs, and also for switching the device on and off.

[0035] Preferably the control means recognises when one or more of the WLEDs has failed and additionally causes a change of state of a further component which indicates that a fault has occurred.

[0036] The further component may be a warning light which can be instantly seen by an engineer, or a memory register in which a bit can be changed and stored for later analysis on connection to the control means of a lighting management system.

[0037] It will be instantly appreciated by those skilled in the art that the device according to the invention can be controlled in a safe and reliable manner and the failures of the WLEDs used in the device can be minimised because of this operation. Furthermore, the constant and continual monitoring of the current flows through the WLED chains further mitigates against failure.

[0038] A further advantage of the device proposed herein is the uniform and relatively low power consumption throughout, for example, an aircraft which can now be achieved.

[0039] A specific embodiment of the invention will now be described by way of example with reference to the following diagram wherein:

Figure 1 shows a possible electronic circuit layout for the control of the device according to the invention.

Figure 2 shows an exploded perspective view of the various components which make up a lighting device according to the present invention, and

Figure 3 shows a plan view of an integrated circuit board on which there is mounted an hexagonal close packed array of WLEDs.

[0040] Referring firstly to Figure 1 there is shown a circuit 2 for providing controllable current through a series of chained WLEDs in accordance with the invention. The circuit comprises high and low voltage lines 4, 6 between which a plurality of chains, three of which are shown at 8, 10, 12 and of which there are ideally 6 are connected in parallel. Each of the chains is provided with three WLEDs 14, 16, 18 connected in series together with a transistor T_X where X is the number from left to right of the particular chain, and a resistor R_X over which there is a measurable potential drop within the particular chain.

[0041] There is additionally provided a power transistor 20 which is connected between the high voltage line 4 and the paralelly connected chains 8, 10, 12. Said power transistor 20 provides a means of altering the total amount of current which is fed from the high voltage line to all of the chains. The high voltage line 4 ideally provides a potential drop over the whole circuit beneath of either 12 or 15V DC, so it will immediately be appreciated that the overall power consumption of the device is relatively small, especially as the WLEDs 14, 16, 18 typically operate at low currents.

[0042] The circuit shown ideally controls the output light of a single WLED cluster comprising only those connected in the chains 8, 10, 12. Many more similar circuits will in practice be connected between the same two voltage lines 4, 6 and will provide light for a number of different seats within an aircraft or like vehicle.

[0043] The control of the currents flowing in the various parts of the circuit is effected as follows.

[0044] The potential drop across all resistors R_X is measured by suitable means and this information is fed to a microprocessor (not shown, but connections thereto are indicated by (M)) which can calculate the currents based on the value of the resistances. Said microprocessor also communicates with and controls the power transistor 20, and the parallely connected transistors T_X, and reduces or increases the current supplied to the bases of said transistors dependent on the current flowing through the resistors R_X.

[0045] The entire circuit is ideally integrated on a printed circuit board (not shown) on which there is further provided a thermistor or like temperature measuring component (also not shown) which provides an indication of the operating temperature of the WLEDs to the microprocessor. Henceforth, the current supplied to all the WLEDs through the power transistor 20, and through each of the chains 8, 10, 12 can be dynamically adjusted by the microprocessor dependent on the operating temperature, the current flow through each of the chains, the total current flow, (although could be derived by the microprocessor from the total of the individual chain currents), and the instantaneous supply voltage.

[0046] The provision of a microprocessor allows for the following operations:

- control of total current through WLEDs by adjustment of base input to power transistor 20 allowing for a dimming cycle and on/off operation of the light;
- reduction of total current and/or individual chain currents as the operating temperature rises according to a prepro-

grammed derating curve;

- compensation for imperfections in the supply line voltage by maintaining a constant total current, known as regulation;
- the automatic reduction to zero of a particular individual chain current in the event that one of the WLEDs in that chain fails in short circuit and subsequent spreading of the total current through the other chains, known as failure compensation which can be additionally limited by temperature compensation;
- automatic compensation for failure of any particular WLED in open circuit in conjunction with current spreading through the remaining chains;
- optional communication with a master controller on the state of health of the WLEDs and the total power consumption.

[0047] A flow chart of the possible operation cycle of the microprocessor and the requirements of the program controlling same may be as follows:

Configure System

START

Measure the current flowing through each chain of WLEDs

Select the required current flow from the state of the user push-button/dimmer switch; The system may be pre-set to have different switching sequences, e.g. On-Off, or ON-Dim-Dimmer-Off, or Ramp Up-Ramp Down

Measure the temperature of the WLEDs

Temperature Compensation
At elevated temperatures apply a proportionate amount of current limiting, thereby extending the life of the WLEDs at higher temperature

Open Circuit Faulty WLED Detection
Check for a lack of current flowing through one or more chains and compensate for this failure by allowing more current to flow through the remaining chains up to a safe limit

Short Circuit Faulty LED Detection
Check for a disproportionately large current flowing through one or more chains and switch off those chains; compensate for these failures by allowing more current to flow through the remaining chains, up to a safe limit

Current Control
Using a proportional plus Integral plus Derivative algorithm, set the current flowing into the WLED chains to meet the requirements determined above; controlling the flow has the advantage that the unit is not voltage dependent and the system will maintain a stable light output over a specified voltage range

Carry out timing and watchdog functions; change state of indication means (i.e. non-white LED, bit in memory register, etc.) if any WLED fails

Return to START

[0048] Referring now to Figures 2 and 3 there is shown a schematic exploded view of some of the components which may be used in the construction of a working lighting device according to the invention.

[0049] An illuminating head is assembled from two shells 100 102, said first shell 100 having an aperture 104 which can receive a transparent insert 106 through which light is emitted. In use, the surface of the shell 100 in which the aperture 104 is provided will typically be directed downwardly above the lap of a user to project light thereon, and therefore this surface is often the under surface of the device.

[0050] Within the two shells is provided a usually black opaque plastic insert 107 having a plurality of bores 108 which at least partially receive the tips of WLEDs 110 mounted on an integrated circuit (IC) board 112. The bores are provided to isolate and insulate each of the WLEDs from one another, to prevent same from interfering with one another, and finally to provide some lateral support for said WLEDs as the terminals by which LEDs are commonly mounted on ICs are prone to fracture. It is to be pointed out that in the embodiment shown in Figure 2, an indicator LED

114 of conventional colour (i.e. red) or alternate colour (e.g. green) is provided substantially centrally within the surrounding array of WLEDs and this particular LED is also received within a substantially central bore 108 within the insert 107.

[0051] Said particular LED, when illuminated in accordance with a modified aspect of the invention to indicate when one or more WLEDs have failed, can be seen through the transparent insert 106 notwithstanding the emission of light through said insert 106 by the remaining illuminated WLEDs. This makes it particularly easy for an engineer or other person inspecting a large number of light fittings to establish whether any particular WLED has failed and thus requires replacement of the cluster at some convenient time subsequently. The timing of the replacement may depend on the maintenance schedule applicable to the particular aircraft in which the device is fitted.

[0052] The end 118 of a flex-and-stay type member 116 is clamped within the aperture defined when the two shells 100, 102 are brought together and a pair of current-carrying wires 120, 122 provide a source of power for corresponding contacts 124, 126 disposed at one end of the IC board 112. It is to be emphasised that the actual manner in which the WLED array is powered is not crucial to the invention, and other methods may be considered by persons skilled in the art.

[0053] Also mounted on said IC board 112 are microprocessor devices 128, 130 which perform the inventive control of supplied current to the various WLED chains which constitute the array, and the particular LED indication means which operates when one or more WLEDs has failed. Other components such as thermistors to measure ambient temperature conditions may also be mounted on said IC board 112 as required by the invention.

[0054] Referring finally to Figure 3, there is shown the particular "hexagonal-close-packed" array 132 of WLEDs mounted on said IC board 112. This arrangement is most desirable because it gives rise to a uniform and balanced light emission from the underside of said shell 100, and these characteristics are not adversely affected when one of the WLEDs fails. Additionally, the particular indication LED 114 can be clearly seen in Figure 3 centrally positioned within the array 132.

Claims

1. A lighting device comprising a cluster of WLEDs at least some of which are chained in parallel between a pair of lines which apply a voltage across the WLEDs chains, each of said chains having at least one WLED therein, characterised in that first current altering means and second and further current altering means are also provided between the lines, said first current altering means being capable of adjusting the total current drawn from the voltage lines by the chained WLEDs and the second and further current altering means being provided in at least one of the chains to adjust the particular current through said chain.

2. A lighting device according to claim 1 characterised in that primary current measuring means are provided between the voltage lines and the chains which provides a representation of the total current being drawn by all the WLED chains.

3. A lighting device according to any preceding claim characterised in that each of the chains is provided with secondary current measuring means.

4. A lighting device according to any preceding claim characterised in that the primary and/or secondary current measuring means communicate with a control means providing same with signals representative of the instantaneous total current drawn and/or that current in a particular WLED chain.

5. A lighting device according to either claim 3 or 4 characterised in that the control means is a microprocessor operating under the control of a computer program which regulates the current flow through the WLEDs dependent on a comparison between the measured current through each individual chain, and optionally through the first current altering means.

6. A lighting device according to any preceding claim characterised in that three WLEDs are connected in series in each of said chains.

7. A lighting device according to any preceding claim characterised in that the number of chains is 6.

8. A lighting device according to any of claims 3-7 characterised in that the secondary current measuring means comprises a resistor connected in series with the series connected WLEDs in each chain.

9. A lighting device according to any preceding claim characterised in that the first and second and further current

altering means comprise transistors.

10. A lighting device according to of claims 4-9 characterised in that the device is provided with temperature measurement means which also communicates with the control means which adjusts the current flow through the WLED chains accordingly.

11. A lighting device according to any of claims 4-10 characterised in that the control means dynamically adjusts the current flows through the WLED chains such that the current flow therethrough is substantially uniform and is devoid of discontinuities regardless of the operating temperature and/or the failure of one or more of the WLEDs.

12. A lighting device according to any of claims 4-11 characterised in that the control means, voltage lines, and chained series connected WLEDs are integrated on a single circuit.

13. A lighting device according to any preceding claim characterised in that the device is used to provide light for a seat, optionally having a source of power built thereinto.

14. A lighting device according to any of claims 4-13 characterised in that the control means also communicates with an indication means changing the state of same when said control means recognises that one or more of the WLEDs has failed.

15. A lighting device according to claim 14 characterised in that the indication means comprises a light means emitting a light other than white, said light means being provided in series with gate means also in communication with the control means between the lines, said control means activating said gate means thus allowing current to flow through the light means to illuminate same only when one or more of the WLEDs has failed.

16. A lighting device according to claim 15 characterised in that said light means is mounted proximate the WLEDs and is visible when the array of WLEDs, one of which has failed, is viewed.

17. A lighting device according to any of claims 14-16 characterised in that the WLEDs and the optional indication means are mounted proximate one another in hexagonal close packed arrangement on a circuit board.

18. A lighting device according to claim 17 characterised in that the control means is also mounted in said circuit board.

19. A lighting device according to claim 18 characterised in that the WLEDs are connected within the circuit board and arranged in groups of three, said group being connected in series as a single chain which is parallely connected with others.

20. A lighting device according to claim 19 characterised in that the grouping of the WLEDs in threes is such that any single WLED is adjacent one other WLED which is connected in series therewith.

21. A lighting device according to claim 14 characterised in that the indication means may be provided in a remote indicator panel and directly powered from the control means.

22. A lighting device according to claim 14 characterised in that the indicator means is manifested in one or more bits in a memory register interrogable by a suitably equipped engineer.

23. A control means for controlling current flow through a plurality of chains connected parallely between a pair of voltage lines, each of said chains having at least one WLED connected therein, current altering means being additionally connected in each of said chains and current measuring means being also provided in each of said chains which communicate with the control means, characterised in that the current flow through each of the chains is altered dependent on a comparison effected by the control means of the current flows through each of the plurality of chains such that the said current flows are maintained substantially uniform.

24. A control means according to claim 23 characterised in that at least a single current altering means, and optionally current measurement means are provided between all of the chains and one of the voltage lines which are capable of altering and measuring respectively the total current flow through the all of the chains.

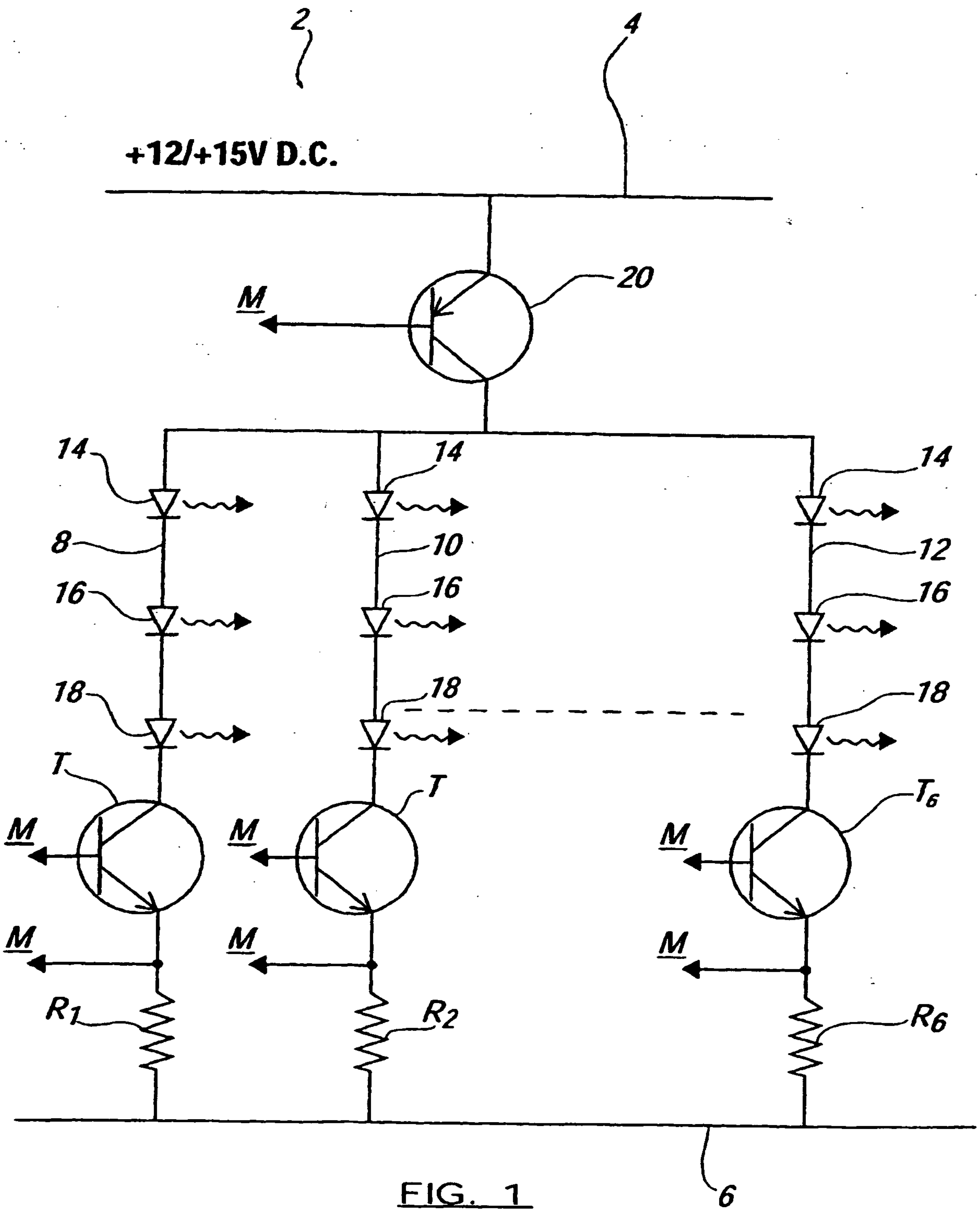
25. A control means according to claim 24 characterised in that said control means also communicates with user

adjustable means for increasing the intensity or dimming the light emitted from the WLEDs, and also for switching the device on and off.

26. A control means according to any one of claims 23-25 characterised in that the control means recognises when one or more of the WLEDs has failed and additionally causes a change of state of a further component which indicates that a fault has occurred.

27. A control means according to claim 26 characterised in that the further component is a warning light which can be instantly seen by an engineer.

28. A control means according to claim 26 characterised in that the further component is a memory register in which a bit can be changed and stored for later analysis on connection to the control means of a lighting management system.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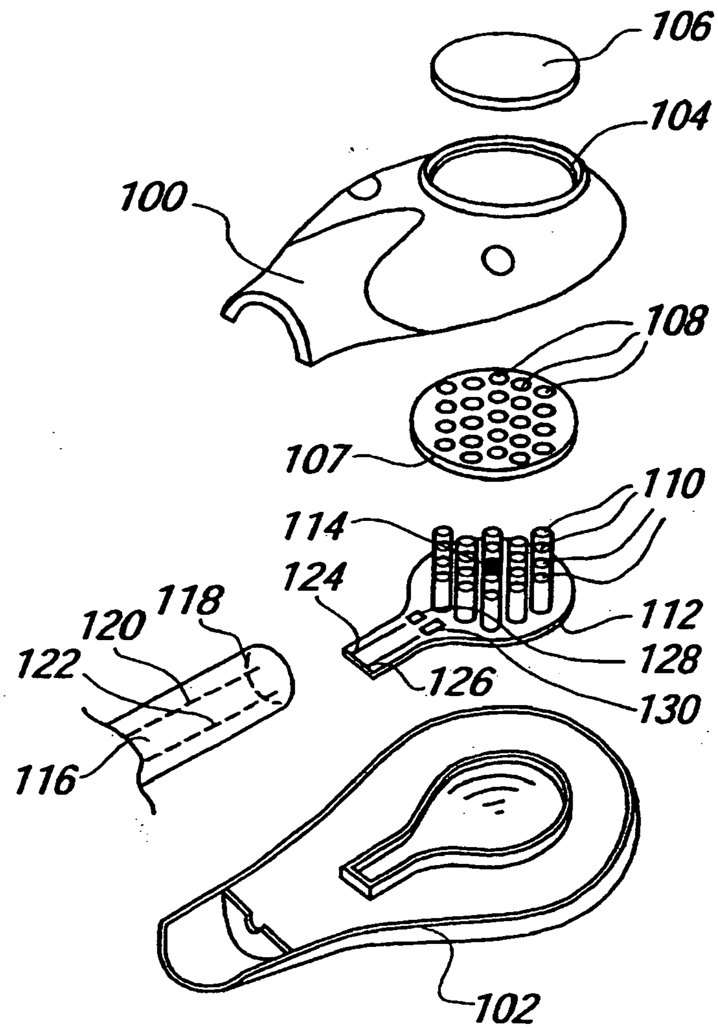
R_6
6

FIG. 1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102

FIG. 2

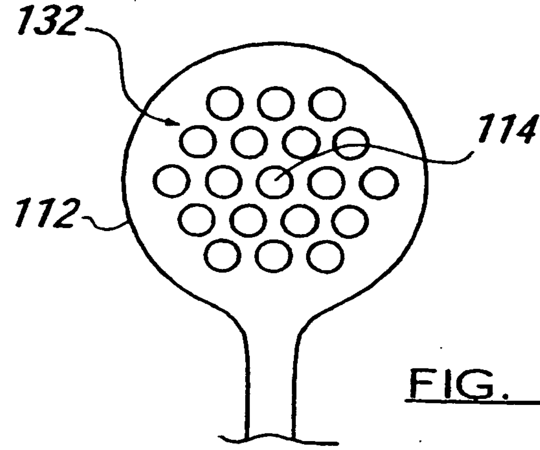
132
114
112

FIG. 3